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DEVELOPMENT OF PROTOTYPE AIR/LIQUID SOLAR COLLECTOR SUBSYSTEM (Sixth Quarterly Report)

Prepared by

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Under Contract NAS8-32259 with

National Aeronautics and Space Administration
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For the U. S. Department of Energy

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16. ABSTRACT

This quarterly report covers the progress made in the development of the SEC-601 collector subsystem by Owens-Illinois under NASA/MSFC Contract NAS8-32259. The report provides a description of thermal and physical performance testing of the Model SEC-601 collector and a forecast of activities for completing contract task.

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Summary

The testing of the 144 tube ERDA evacuated tubular air collector in conjunction with an air/liquid heat exchange and liquid storage elements was completed. Test results indicate care is needed to match the heat exchanger and collector characteristics with specific attention to the dynamic response of each of the elements. The thermal and physical performance testing of the Model SEC-601 collector was essentially completed during the reporting period. Formal documentation of the results of the verification and test analysis was submitted for many sections of the test plan. No problems or surprises have been experienced to date.

Technical Performance

A. General description of work accomplished during the reporting period.

1. The assembly of manifolds No. 2 and No. 3 was completed in early February 1978. Leakage flow tests of each of the two units demonstrated that the leakage flow rate was less than the 1.0% of the design air flow rate target. A minimum leakage flow is required in an air cooled collector to control thermal losses of a system. Make up air to accomodate system leakage is normally at ambient temperature while the overboard leakage air is at system temperature which with a high performance collector could be 250°F and above. The next most critical test was considered to be the ability of the air manifold to operate reliability after thermal cycling from essentially ambient air temperature to in excess of 300°F air temperature. The effect of differential expansion of the materials in the manifold represented a most difficult analytical problem. The No. 2 manifold was thermally cycled from essentially room ambient temperature to 325°F air temperature with the air flow in the manifold at essentially the design air flow rate of 8 pounds per hour-feet^2. The manifold leakage flow rate of the fully assembled 72 tube module was measured periodically throughout the test period. No significant change in leakage flow rate could be

detected. The completion of these two critical tests predict highly satisfactory results for all the remaining tests and evaluations.

2. Prototype Design Review

An Engineering Change Notice is in final draft for formal internal approval of the minor design changes introduced in the fabrication of units No. 2 and No. 3 from the approved base line design. Preparations were completed for the release for fabrication of the four (4) deliverable collector modules. Formal release to manufacturing is expected by early May, 1978.

3. Verification Tests.

The tests and analysis required by the Verification Test Plan were essentially completed during the reporting period. The remaining tests include the extended outdoor tests at DSET, one or two more test points on the thermal performance test map and two structural tests. Documentation has been completed on over 60% of the tests of Section 1.0 through 5.0. Completion of the test and documentation for these sections of the Verification Test Plan are expected on schedule.

4. Air Collector Performance and Operational Testing.

Problems were indicated in the last quarterly report relative to the sensing of insolation in the plane of the collector. Further investigation suggested that others were having similiar problems; viz., the accuracy of measurement of an Eppley 8 - 48 at tilt angles relative to the horizontal and hour angles away from solar noon. Therefore, the more recently purchased Eppley PSP will be used as the primary measurement of total insolation in the plane of the collector for purposes of analysis and reporting of thermal performance. A model 8 - 48 with shadow band will be used for the measurement of diffuse radiation in the plane of the collector.

Unit No. 3 was installed on the roof and fluid flow tests were initiated in late February. The assembled module was tested for leakage flow rate prior to mounting at the test site. The leakage flow rate was less than 0.1% of the collector flow rate throughout any reasonable range of operation.

The leakage flow was measured for manifold pressures as follows:

Manifold Pressure, inches w.g.	1.0	2.0	3.0	4.0	5.0
Measured leakage flow, Ft^3/Min	.035	.060	.081	.099	.113

The Model SEC 601 air flow pressure drop relationship as determined empirically is:

$$\Delta P = \frac{CFM}{U5}^{1.83} \text{ /tube}$$

where:

CFM = volume flow/tube

ΔP = collector pressure drop, inches, w.g.

For the 72 tube module, the flow rate for a given pressure drop is:

$$CFM/_{tube} = (\Delta P \times 15)^{1/1.83} \times 72$$

Model SEC 601 volume Flow Ft^3/min	316	462	576	675	
Collector pressure drop, inches w.g.	1.0	2.0	3.0	4.0	5.0
Measured leakage flow rate Ft^3/min	.035	.060	.081	.099	.115
% Leakage flow/volume flow	.0001	.0001	.0001	.0001	.0002

Following the roof installation of the collector and just prior to the completion of the air flow ducting under the roof, an additional leakage flow test was completed. The exit air duct was taped shut. The air fan speed was increased to produce a manifold pressure of 2.0 inches w.g. A smoke bomb was ignited and placed in the fan inlet for ingestion of the smoke into the module. No smoke tracer, indicating air leakage from the module, could be detected.

Thermal performance testing was initiated in early April, 1978. The thermal storage temperature was preset at temperatures between city water line temperature and about 180°F, the maximum temperature setting of the existing thermostat. The air fan and water pump were operated throughout the night to establish an initial operating condition at sunrise. The collector air inlet temperature was held essentially constant by mixing city water with the heat exchange discharge water and dumping the excess water to drain. The computer analysis program was not operable during the reporting period. The problem appears to be the transfer of data from the acquisition magnetic tape to computer storage. A hand analysis of one day of testing yielded a single day test point of $\bar{n} = .58; \Delta\bar{T} / \bar{I}_{1p} = .15$.

5. Installation, Operation and Maintenance Manual.
The preliminary document, previously submitted was reviewed. It is now considered to be too detailed in content. The design data brochure is being reviewed by Corporate Staff. With some expansion, this design data brochure could also meet the requirements of the installation, operation and maintenance manuals for near term purposes.

B. Forecast of Activities to Complete Tasks.

1. Units No. 4 through No. 7 have been released for fabrication. All detail components and subassemblies are scheduled for delivery to the Development Center by the first week of June, 1978. It is anticipated that unit No. 4 will be assembled in time for first article review by mid June.
2. Steps have been taken to correct the problem of the data acquisition-computer interface. The test loop has been modified to allow 100% ingestion of ambient air into the collector fan inlet and 100% overboard dump of the effluent. The "Y" intercept ($\Delta \bar{T} / \bar{I}_{TP} = 0$) is the last data point required to complete the thermal performance testing of the collector.
3. The structural tests (Section 3) are essentially complete. A preliminary review of the data indicates that no exceptions to the IPC criteria will be required. It is expected that all documentation will be completed for Sections 1 through 5 by the end of May. The completion of the Installation, Operation and Maintenance Manual by Mid June, 1978, could present schedule problems; however, every possible attempt to complete the documentation on schedule will be made.

D. Data Submittals

Reference	Description
259-60	Technical Directive 06
259-61	Qualification Test and Analysis Report - IPC 2.6
259-62	Acceptance Test Procedures
259-63	Reorganization of SUNPAK™ Group
259-64	Quarterly, Monthly and Cross-Charge Reports, January, 1978
259-65	Monthly and Cross-Charge Report, February, 1978
259-66	Updated IPC Test Schedule
259-67	Dissemination of Design Review Data
259-68	Modification No. 4

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